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(54) MANUFACTURING METHOD OF MICROMACHINE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a manufacturing method of micromachine in which the freedom of selection of a substrate is increased by a novel method to allow the use of an inexpensive substrate and also allow the manufacture of a structure having a large difference in level.

SOLUTION: Au/Ti films (2, 3, 4, 12a, and 12b) forming an insulating layer 5 and a line conductor or control electrode are formed on a high resistance silicon-substrate 1, and an insulating layer 6 is formed thereon. A copper film 20 as conductive sacrifice layer is formed on the substrate 1. A photoresist 22 is formed thereon, an amorphous Ni-P film 8 is accumulated on the substrate 1 including the Cu-sacrifice layer 20 by electroless plating method (electroless Ni-P plating). The Cu

sacrifice layer 20 is removed by etching to make the amorphous Ni-P film 8 into a beam structure.

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CLAIMS

[Claim(s)]

[Claim 1] The production approach of the micro machine characterized by having the process which forms a sacrifice layer on a substrate, the process which deposits an amorphous metal membrane by the electroless deposition method on said substrate including said sacrifice layer top, and the process which removes said sacrifice layer by etching and makes said amorphous metal membrane beam structure.

[Claim 2] Said electroless deposition is the production approach of the micro machine according to claim 1 characterized by being non-electrolyzed nickel-P plating.

[Claim 3] Said sacrifice layer is the production approach of the micro machine according to claim 1 or 2 characterized by being what has conductivity.

[Claim 4] The sacrifice layer which has said conductivity is the production approach of the micro machine according to claim 3 characterized by being a copper film.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the production approach of the micro machine which used the surface micro-machining technique.

[0002]

[Description of the Prior Art] In order to form the detailed structure in recent years and to produce an electrostatic switch, a sensor, etc., development of a micro machine

technique is performed energetically. The micro machine which used for the structure the polycrystalline silicon which is typical structure is produced at the process based on the making process of a silicon integrated circuit. Therefore, there is a fault of being unable to make the structure with a large level difference which can use only the substrate with which the thermal resistance of silicon (Si) etc. has process temperature highly. In order to compensate this fault, the structure is proposed as follows. (1) The structure which combined the stanchion made of resin, and the aluminum thin film (John N.Randall, Chuck Goldsmith et. al, J. Vac, Sci, technol. B/4 (6), p. 3692 - 3696 (1996)). (2) The structure using nickel plating (Paul M.Zavracy, Nicol E.McGruer et.al, and Proc.Sens.Eypo.Detroit.p.293 -298 (1997)). However, there is a problem in respect of the reinforcement of the structure.

[0003]

[Problem(s) to be Solved by the Invention] This invention is made under the above backgrounds and that purpose is in offering the production approach of the micro machine which enables production of the structure with a big level difference by new technique, while enabling use of the increase of the degree of freedom of selection of a substrate, and a cheap substrate.

[0004]

[Means for Solving the Problem] According to the production approach of a micro machine according to claim 1, a sacrifice layer is formed on a substrate and an amorphous metal membrane accumulates by the electroless deposition method on a substrate including a sacrifice layer top. And etching removes a sacrifice layer and an amorphous metal membrane is made into beam structure.

[0005] Thus, the structure which was excellent in mechanical strength can be formed by depositing an amorphous metal membrane on a sacrifice layer in ordinary temperature using electroless deposition, without carrying out a stage piece also in the location where a level difference is large. Consequently, while enabling use of the increase of the degree of freedom of selection of a substrate, and a cheap substrate, it becomes producible [the structure with a big level difference].

[0006] When non-electrolyzed nickel-P plating is used for claim 2 as electroless deposition like a publication here, it is desirable practically. Under the present circumstances, it will become practically desirable if a copper film is used for the thing according to claim 3 which has conductivity, especially claim 4 like a publication as a sacrifice layer like.

[0007]

[Embodiment of the Invention] Hereafter, the gestalt of the operation which

materialized this invention is explained according to a drawing. It is realized on the electrostatic switch (in detail capacity-coupling mold electrostatic switch) which forms some millimeter wave integrated circuits in this operation gestalt. The perspective view of the electrostatic switch in this operation gestalt is shown in drawing 1 . Moreover, the top view of an electrostatic switch is shown in drawing 2 . Furthermore, the longitudinal section in the A-A line of drawing 2 is shown in drawing 3 .

[0008] The high resistance silicon substrate is used for the substrate 1, and the resistance is more than 1000-ohmcm. Conductors 2, 3, and 4 are installed on the high resistance silicon substrate 1, and the coplanar waveguide is constituted. that is, a substrate 1 top -- the object for glands -- while conductors 3 and 4 are installed -- the object for glands -- the transmission line 2 has extended among conductors 3 and 4. Conductors 2-4 consist of Au/Ti. In addition, an insulating layer 5 is formed in a field without the conductors 2-4 on a substrate 1, and an insulating layer 5 consists of silicon oxide (SiO2). An insulating layer 6 is formed on conductors 2, 3, and 4 in the middle of the track, and an insulating layer 6 consists of a silicon nitride (Si3 N4). an insulating-layer 6 top -- an opening 7 -- minding -- the object for the switch of beam structure -- the conductor 8 is arranged. the object for a switch -- amorphous nickel-P which is an amorphous metal is used for the conductor 8.

[0009] the object for the switch of beam structure -- as a flat-surface configuration, it had the four support sections 9a, 9b, 9c, and 9d, Beams 10a, 10b, 10c, and 10d were prolonged from the support sections 9a, 9b, 9c, and 9d, and the conductor 8 is connected with the rectangle section (counterelectrode section) 11, as shown in drawing 2 . the rectangle section 11 -- the object for tracks -- it is located on conductors 2, 3, and 4. While the support sections 9a and 9b are fixed on control-electrode 12a, the support sections 9c and 9d are being fixed on control-electrode 12b. Control electrodes 12a and 12b consist of Au/Ti. it is shown in drawing 3 -- as -- the object for a switch -- a conductor 8 and the object for glands -- while capacity C1 and C2 is formed among conductors 3 and 4 -- the object for a switch -- capacity C3 is formed between a conductor 8 and the transmission line 2.

[0010] and -- the condition that an electrical potential difference is not impressed to control electrodes 12a and 12b -- the object for a switch -- the rectangle section (counterelectrode section) 11 of a conductor 8, and the object for glands -- conductors 3 and 4 and the transmission line 2 are held at predetermined interval. In this condition, the millimeter wave transmits the track. if alternating voltage is impressed to control electrodes 12a and 12b from this condition on the other hand -- the object for a switch, as the rectangle section 11 of a conductor 8 can draw near to a substrate 1 side and it is

shown in drawing 4 the object for a switch -- the rectangle section 11 of a conductor 8, and the object for glands -- the distance of conductors 3 and 4, and the distance of the rectangle section 11 and the transmission line 2 -- small -- becoming (capacity C1, C2, and C3 decreasing) -- the transmission line 2 and the object for glands -- since between conductors 3 and 4 connects too hastily to a RF, termination of the track is carried out. Therefore, the millimeter wave which has transmitted the transmission line 2 is reflected in the part concerned. Thus, it functions as a switch which permits / intercepts passage of a millimeter wave.

[0011] Next, the process which produces this capacity-coupling mold electrostatic switch is explained using drawing 5 and drawing 3 . First, as shown in drawing 5 (a), the high resistance silicon substrate 1 is prepared. and the silicon oxide (SiO2) 5 which is an insulating layer on the high resistance silicon substrate 1 and the object for tracks -- the Au/Ti film (2, 3, 4, 12a, 12b) used as a conductor or a control electrode is formed by the photolithography.

[0012] Furthermore, as shown in drawing 5 (b), patterning of the silicon nitride (Si3 N4) 6 used as an insulating layer is deposited and carried out on the silicon oxide 5 on the high resistance silicon substrate 1, and the Au/Ti film (2, 3, 4, 12a, 12b).

[0013] Then, as shown in drawing 5 (c), the copper film 20 used as a sacrifice layer is formed on a substrate 1, and opening of the part 21 which serves as the support section of the structure to a copper film 20 is carried out further. Then, as shown in drawing 5 (d), patterning of the photoresist 22 is carried out. And the amorphous nickel-P film 8 is deposited on a substrate 1 by electroless deposition. That is, the amorphous nickel-P film 8 is deposited to the part (part 21 used as Cu sacrifice layer 20 top and the support section) exposed from the photoresist 22 on a substrate 1. The temperature when performing this non-electrolyzed nickel-P plating is about 90 degrees C.

[0014] Then, after removing a photoresist 22, Cu sacrifice layer 20 is removed by etching. The mixture of the 2nd copper of ammonium chloride and ammonia is used for an etching reagent. consequently, it is shown in drawing 3 -- as -- the object for a switch -- a conductor (amorphous nickel-P film) 8 and the object for tracks -- an opening 7 forms among conductors (Au/Ti) 2, 3, and 4 -- having -- the object for a switch -- Beams 10a-10d and the rectangle section (counterelectrode section) 11 of a conductor 8 dissociate from a substrate 1 side. Thus, the amorphous nickel-P film 8 is made into beam structure by sacrifice layer etching, and production of an electrostatic switch is completed.

[0015] As mentioned above, formation of the structure is attained, without using a hot (for example, 1000 degrees C) process like the making process of a silicon integrated

circuit by non-electrolyzed nickel-P plating using deposition of the amorphous metal which excelled [ordinary temperature / (0-100 degrees C)] in mechanical strength being possible. So, while enabling use of the increase of the degree of freedom of selection of a substrate, and a cheap substrate, the step coverage of plating is used and it becomes possible to produce the structure with a big level difference.

[0016] Heat-resistant temperature of a glass substrate is 500 degrees C or less, and, more specifically, heat-resistant temperature of a plastic plate (resin substrate) is about 150 degrees C. It becomes possible to use such a cheap substrate.

[0017] Thus, the gestalt of this operation has the following description.

(b) As the production approach of a micro machine, as shown in drawing 5 (c) As it is indicated in drawing 5 (d) as the process which forms the copper film 20 as a sacrifice layer which has conductivity on a substrate 1 As etching removes Cu sacrifice layer 20 and it is indicated in drawing 3 as the process which deposits the amorphous nickel-P film 8 which is an amorphous metal membrane by the electroless deposition method (non-electrolyzed nickel-P plating) on the substrate 1 including Cu sacrifice layer 20 top It had the process which makes the amorphous nickel-P film 8 beam structure. Thus, the structure which was excellent in mechanical strength can be formed by depositing the amorphous nickel-P film 8 on Cu sacrifice layer 20 in ordinary temperature using electroless deposition, without carrying out a stage piece also in the location where a level difference is large. Consequently, while enabling use of the increase of the degree of freedom of selection of a substrate, and a cheap substrate, it becomes producible [the structure with a big level difference].

[0018] In addition, an actuator, a sensor, etc. can be mentioned other than the electrostatic switch which has the detailed structure as a concrete application of the micro machine of this invention. Moreover, as an amorphous metal, although amorphous nickel-P was used, other amorphous metals, for example, nickel-B etc., may be used.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The perspective view of the capacity-coupling mold electrostatic switch in the gestalt of operation.

[Drawing 2] The top view of a capacity-coupling mold electrostatic switch.

[Drawing 3] Drawing of longitudinal section in the A-A line of drawing 2 .

[Drawing 4] The explanatory view of an electrostatic switch of operation.

[Drawing 5] The process explanatory view which produces an electrostatic switch.

[Description of Notations]

1 -- quantity resistance silicon substrate, 2 and 3, and 4 -- a conductor, 5 -- insulating layer, and 6 -- an insulating layer, 7 -- opening, and the object for 8 -- switch -- the copper film used as a conductor and 20 -- sacrifice layer.